Handbook for Restoring Native Animals

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Natural Resources Report NPS/NRPORE/NRR-95/19

United States Department of the Interior • National Park Service • Point Reyes National Seashore

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Natural Resources Report NPS/NRPORE/NRR-95/19

June 1995

United States Department of the Interior
National Park Service
Natural Resources Publication Office
Denver, Colorado

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Acknowledgements

We appreciate the time and effort of the managers, biologists, and resource professionals who responded to our surveys. The respondents provided detailed information and insightful comments about their programs. We thank B. Griffith for discussions about surveys and about the biology and restoration of native animals. R. McBride assisted with the design of the survey and with the statistical analysis and interpretation. R. Brown, R. Cook, and J. Fellers provided valuable comments on an earlier draft. The National Park Service funded this study.

Project Overview

We combined information from two mail surveys and from a review of the literature on native animal restoration projects. The surveys were used to determine which agencies have conducted restoration projects, the species with which they are working, the methods used, and the factors related to successful and unsuccessful projects. The literature review focused on published accounts of reintroduction projects and recommendations by other authors on the restoration process.

This handbook is intended to provide park managers, resource specialists, and biologists with guidelines that will allow them to determine whether a restoration program is feasible and, if so, assist them in the planning and implementation of a successful project.

Introduction

Humans have moved animal species from one area to another ever since prehistoric times. Many translocations were inadvertent, as with rats, mice, and other species that "stowed away" when people moved from one area to another. Others were purposeful, with game species or semi-domesticated animals that were released for hunting or other practical uses (Elton 1958, Collins 1991). These movements have involved both translocations of the species from one area of its range to another and introductions into new areas outside a species original range.

Restoration (i.e., the restoration of an animal to a portion of its range where it has been lost) is more recent. Intentional restorations were mainly of game species. In a survey of state game agencies, most translocations (57%) were conducted to restore native species to areas where they had been extirpated (Boyer and Brown 1988). The species translocated most frequently were black bear, white-tailed deer, elk, and bighorn sheep. In Alaska, the species moved most frequently were black-tailed deer, red fox, muskox, and elk (Burris and McKnight 1973, Franzmann 1988). In an extensive survey that covered more than 90 species of native birds and mammals in Australia, Canada, New Zealand, and the United States between 1973 and 1986, translocations of game species made up 90% of an estimated 700 translocations per year (Griffith et al. 1989).

In the past two decades, restoration programs have included more projects for conservation purposes (Franzmann 1988, Nielsen and Brown 1988). An increasing number of translocations are for rare species. Seven percent of the projects reviewed by Griffith et al. (1989) were conducted for rare and endangered species. Perhaps the best-known and most extensive restoration project of this type is the captive breeding and restoration of peregrine falcons (Cade et al. 1988, Newton and Chancellor 1985). Other large-scale, intensive restoration efforts include those for bighorn sheep, California condors, and black-footed ferrets. Although the most familiar examples involve large mammals and birds, restoration efforts have been attempted using a wide range of species, from small mammals such as the fox squirrel in the eastern United States to several threatened trout in the West, and insects such as the Atala butterfly in the Everglades.

Restoration projects are also designed to return communities to a more nearly pristine condition (Gogan 1990). A fundamental objective of natural resource management in parks is to maintain or restore natural conditions (U.S. Department of the Interior, National Park Service 1991). The restoration of extirpated species is important. An outstanding example of recreating a community is seen at Gateway National Recreation Area, where essentially an entire reptile and amphibian community was restored in reclaimed and natural habitats. Most of the 11 species of reptiles and amphibians are reestablished (Cook and Pinnock 1987).

Several authors outlined procedures and commented on the factors responsible for successful restorations. Most notably, Nielsen (1988) stressed careful planning, including an in-depth feasibility study, professional guidance, and adequate funding. The biology of restored species and aspects of the restoration process itself have been analyzed for projects carried out in the United States by state fish and game departments from 1973 to 1986 (Griffith et al. 1989). They evaluated habitat quality, the location of the restoration area within the range of the entire species, the number of individuals released, the length of the project, and the life history traits of the restored species as correlates of success. They also noted the lack or inaccessibility of information on past projects and urged that careful records be kept, both for unsuccessful and successful projects.

In a survey by Boyer and Brown (1988), the most common problems encountered by state agencies with translocation efforts were:

- obtaining animals for release (32% of the agencies surveyed)
- death of animals during capture and handling (31% of respondents)
- availability of sufficient funds, personnel, and time
- loss of animals at the release site (due to predation, poaching, dispersal, or other causes)
- concerns about introducing disease with the restored animals

Insufficient funding and personnel were the main reasons more restorations were not attempted.

Need for Survey and Handbook

In parks and reserves, restoration programs may by undertaken as part of recovery projects for rare and endangered species. Restoring native species helps restore natural conditions and contributes to protecting natural ecosystems. Reintroducing native species is specifically included in the National Park Service (NPS) *Management Policies* (U.S. Department of the Interior, National Park Service 1988):

> The National Park Service will strive to restore native species to parks wherever all the following criteria can be met:
>
> Adequate habitat to support the species either exists or can reasonably be re-created in the park and, if necessary, on adjacent public lands and waters.
>
> The species does not, based on an effective management plan, pose a serious threat to the safety of park visitors, park resources, or persons or property outside park boundaries.
>
> The subspecies used in restoration most nearly approximates the extirpated subspecies or race.
>
> The species disappeared or was substantially diminished as a direct or indirect result of human-induced change to the species population or to the ecosystem.
>
> Such programs will be carried out in cooperation with other affected agencies, organizations, and individuals.

Other agencies also have official guidelines for reintroducing native animals. For example, the U.S. Fish and Wildlife Service (USFWS) permits for introducing animals where the introductions are in agreement with management objectives of the refuge. The species introduced must be (or have been) native to the area; background information on life history, population dynamics (including present trend in population), behavior, habitat needs, and general ecology must be available (Franzmann 1988).

Reintroducing an animal into an area from which it has disappeared is an involved undertaking, and results of past efforts have been mixed. A number of authors have, in fact, argued against restoration projects because of their expense and poor record of success (e.g., Dodd and Seigel 1991). Nielsen (1988) notes that considerable resources have been wasted on poorly thought-out projects. Other authors contend that the "real business of wildlife conservation" lies in protecting habitats, and restoration projects should be undertaken only in a protected natural community (Caldecott and Kavanaugh 1988).

Progress has been made in using restorations to restore viable populations, but careful consideration of the entire process is still needed. A successful restoration requires understanding the species to be restored, analyzing the potential habitat for the species, considering threats to the success of the new population, planning the various steps in actually bringing the species in and releasing it, and following up the evaluations on success and progress of the new population. The results of previous work have been poorly documented, and a comprehensive compilation is lacking. Hence, individuals seeking to carry out new restorations may not be able to learn much from the previous work. Further, restoration projects will likely be conducted more frequently and by more agencies in the coming years.

Our intent is to bring together in one place important information and references on this subject. Specifically, our goals are to:

1. collect information from a range of geographical areas, habitat types, and management strategies
2. evaluate the factors involved in the success or failure of restoration efforts for native animals
3. provide biologists and administrators with guidelines for reviewing, prioritizing, and planning restoration projects
4. provide a compendium of information for implementing restoration projects

This handbook provides a starting point for those who are initially planning a restoration project, or it may provide supplemental information for individuals whose projects are in a more advanced stage of deveopment.

Methods

Mail Surveys

The results of most projects to restore native animals are unpublished. We used two mail surveys to gather information from individuals in parks and other land management agencies involved with restorations. Both surveys closely followed Dillman (1981) in the wording, the arrangement of questions, and the manner in which the surveys were administered.

The preliminary survey was designed to provide an overview of which parks were involved in restoration projects and which species were of most concern (see Appendix A for complete text). The preliminary survey also asked questions about removing nonnative animals. The results of that portion of our research are summarized in the companion handbook on removing nonnative animals (Drost and Fellers, *in prep.*).

As summarized in Table 1, the preliminary survey was sent to:

- all U.S. national parks, national forests, Bureau of Land Management field areas, and USFWS-administered national wildlife refuges and similar areas
- all Canadian national parks
- a sampling of provincial and national parks in Australia
- all state parks in California and Texas
- all private preserves managed by the National Audubon Society and the Nature Conservancy (in the United States)

The first survey was mailed August 1, 1990. A follow-up letter and another copy of the survey were mailed on October 1, 1990, if a response had not been received.

Table 1. Individuals from land management agencies responding to the two mail surveys on restoring native species.

Country and Agency	Number of Responses	
	Preliminary Survey	Detailed Survey
United States		
National Park Service	318	60
Fish and Wildlife Service	233	60
Forest Service	101	65
Bureau of Land Management	86	43
California State Parks	50	7
Texas State Parks	92	8
Audubon Society	32	4
Nature Conservancy	25	6
Canada		
National Parks	51	12
Australia		
National and Provincial Parks	29	9
Total	1,017	274

All respondents who completed, or were currently working on, restoration projects were sent a second follow-up survey, unless they indicated in the first survey that they could not respond to further inquiries. Some respondents referred us to other people or agencies in the preliminary survey, and we redirected the second survey to the new contact whenever possible.

For the follow-up survey, we selected one species that the respondents worked on (based on their response to the preliminary survey) and asked the respondents to answer the questions about that species. We selected these target species based on (1) the usefulness of information to others working on the same or similar species, (2) the need for an adequate sample size for commonly listed species (e.g., peregrine falcon, bighorn sheep), and (3) an attempt to cover a range of taxa and projects. The full text of the survey is reproduced in Appendix B.

The follow-up survey was mailed on March 12, 1991. Individuals who had not responded by the beginning of May were sent a follow-up letter and a second copy of the survey on May 6. A final reminder letter was sent on August 19, 1991, to those individuals that had not returned the survey by that time.

Statistical Analysis

Responses to the questions in the detailed survey were summarized in frequency tables. Some variables were recorded to facilitate analysis; open-ended, fill-in questions (e.g., habitat type, population estimates) were assigned to categories wherever possible. The success variable was recorded for the analysis as well. Projects listed as "still in progress," which had been going on for 10 years or more, were recorded as "unsuccessful."

The bivariate relation between our success variable and other variables was examined using Chi-square tests with a two-tailed significance level of 0.1. A series of logistic regression models comparing success against all independent variables also was run using both stepwise and backward algorithms for inclusion or exclusion of variables from the model. The regression was conducted to evaluate the effect of all variables taken together on success and to identify which variables were significantly associated with successful programs. Significance levels of 0.05 and 0.10 were used for acceptance or rejection. All analyses were conducted using the SPSS/PC statistical program (Norusis 1990).

Bibliography

In addition to the mail surveys, we conducted an extensive literature review for articles on animal restorations. (A printed copy of this bibliography on disk in IBM- compatible dBase format is available from authors.) Published references were obtained using both the BIOSIS and SCISEARCH computerized bibliographic databases (Dialog, Menlo Park, California). The NITC bibliographic database (at the main library of the University of California at Davis) was used to search the government literature for additional reports. References were also extracted from the literature cited sections of major reviews of animal restoration work (e.g., Nielsen and Brown 1988). We also reviewed several major conservation journals (*Biological Conservation, Conservation Biology, Journal of Wildlife Management*) for pertinent references.

We concentrated on articles about the practical aspects of animal restoration (e.g., movements and homing of transplanted animals, minimum population size, and the genetics of small populations). Our attention was focused on papers that presented new information or comprehensive data for a particular species or area. Within this context, we emphasized:

- case studies (results of projects in particular areas)
- methods used for translocating species for restoration purposes
- biological and ecological aspects of species of management concern where they were important to restoration efforts

Most of the references describe work conducted in North America, Australia, and, to a lesser extent, New Zealand and Europe.

We did not include most theoretical papers on the ecology of introductions or short status papers.

References were entered into a dBase file with fields for taxon, geographical area, and keyword in addition to the reference information itself. Abstracts were written for selected references that contained the practical aspects of native animal restoration. Geographical area, taxonomic group of the species concerned, and keywords were drawn from the article and entered into the database.

Results

Survey Response

We sent the initial survey to 1,188 potential respondents in the United States, Canada, and Australia. Of these, 33 responded that the survey was not appropriate for their site. These were mostly small historic sites, monuments, or other locations with little or no wildland component. Data from an additional 52 of the original recipients were combined with other locations on our list because they were contiguous or were contained within another location and were managed jointly. This left an effective sample of 1,103 land managers. Of these, 1,017 returned completed surveys (92%). The excellent response rate provided information from a wide range of habitats from all parts of the United States and from representative locations in Canada and Australia (Table 1).

We sent detailed, follow-up surveys to managers at 344 parks and other land management areas. Eleven replied that they did not consider the survey appropriate for their agency, which reduced the sample to 333. Surveys were returned by 297 managers (89%). Of these, 28 were either incomplete or unusable for some other reason. Some managers, however, returned extra copies of the questionnaire for additional restoration projects being conducted, so we had 274 usable returns.

Agencies Involved in Restoration Programs

On the average, 29% of the surveyed managers were conducting restoration projects, and 28% had completed a project. The NPS respondents were below average in both categories (16%, 16%) and the lowest of the four federal agencies surveyed (Table 2). Australian park managers had completed (18%) or were working on (12%) projects at about the same rate as the National Park Service, but Canadian park managers were above average in both categories (32% and 41%). Areas managed by the Nature Conservancy and Audubon Society were average, but the state park managers in Texas and California have been involved in relatively few restorations.

Restoration projects managed in both the U.S. Forest Service and the Bureau of Land Management were notably above the average. Perhaps that would be expected for the Forest Service because much of their land is used for timber harvest, and restoration is a routine part of that operation.

Species Involved in Restoration Programs

Bighorn sheep (Table 3) were being restored in the most (146) locations, followed by peregrine falcon (107), wild turkey (65), elk (55), and river otter (38). Cutthroat trout was the highest ranking fish (29), while American alligator (5) and red-legged frog (2) were the most frequent reptiles and amphibians. The pismo clam (2) was one of the few invertebrates.

Mammals made up 49% of the animals being restored, with birds (36%), fish (11%), reptiles (3%), amphibians, (1%), and invertebrates (0.1%) following (Table 4). This distribution reflects the generally greater interest in the higher taxa. However, reestablishing populations of invertebrates and lower vertebrates may be easier. For example, the model program at Gateway National Recreation Area showed that restoring gray treefrogs was quick, easy, and inexpensive. This example suggests a need to give greater consideration to the lower groups.

Table 2. Proportion of individuals representing management areas who responded that restoration programs were ongoing or completed (preliminary survey questions 6 and 7) in their management area.

Country and Agency	Restorations	
	Ongoing(%)	Completed(%)
United States		
National Park Service	15.9	16.3
Fish and Wildlife Service	26.2	29.5
Forest Service	71.0	63.0
Bureau of Land Management	67.1	60.0
California State Parks	25.0	8.3
Texas State Parks	8.8	8.8
Audubon Society	25.0	12.5
Nature Conservancy	25.0	25.0
Canada		
National Parks	32.0	41.4
Australia		
National and Provincial Parks	18.0	12.2
Average	29.2	27.6

Table 3. Species being restored in national parks, national forests, national wildlife refuges, and other protected areas in the United States, Canada, and Australia (see Table 1 for a complete list).

No. of Areas	Common (Scientific)	No. of Areas	Common (Scientific)
146	Bighorn sheep (*Ovis canadensis*)	4	Caribou (*Rangifer tarandus*)
107	Peregrine falcon (*Falco peregrinus*)	4	Gila trout (*Salmo gilae*)
65	Wild turkey (*Meleagris gallopavo*)	4	Greater prairie-chicken (*Tympanuchus cupido*)
55	Elk (*Cervus elaphus*)	4	Rainbow trout (*Salmo gairdneri*)
38	River otter (*Lutra canadensis*)	3	Atlantic puffin (*Fratercula arctica*)
29	Cutthroat trout (*Salmo clarki*)	3	Brook trout (*Salvelinus fontinalis*)
29	Pronghorn (*Antilocapra americana*)	3	Brown pelican (*Pelecanus occidentalis*)
27	Canada goose (*Branta canadensis*)	3	Coho salmon (*Oncorhynchus kisutch*)
23	Bald eagle (*Haliaeetus leucocephalus*)	3	Eastern bluebird (*Sialia sialis*)
18	Mountain goat (*Oreamnos americanus*)	3	Giant kangaroo rat (*Dipodomys ingens*)
15	Bison (*Bison bison*)	3	Gila topminnow (*Poeciliopsis occidentalis*)
15	Marten (*Martes americana*)	3	Great grey kangaroo (*Macropus giganteus*)
15	Moose (*Alces Alces*)	3	Muskox (*Ovibos moschatus*)
14	Black-footed ferret (*Mustela nigripes*)	3	Northern bobwhite (*Colinus virginianus*)
14	White-tailed deer (*Odocoileus virginianus*)	3	Sage grouse (*Centrocercus urophasianus*)
13	Sharp-tailed grouse (*Tympanuchus phasianellus*)	3	Thick-billed parrot (*Rhynchopsitta pachyrhyncha*)
12	Beaver (*Castor canadensis*)	3	Tui chub (*Gila bicolor*)
12	Fisher (*Martes pennanti*)	3	White-tailed ptarmigan (*Lagopus leucurus*)
12	Trumpeter swan (*Cygnus buccinator*)	2	Atlantic salmon (*Salmo salar*)
10	Utah prairie dog (*Cynomys parvidens*)	2	Barn owl (*Tyto alba*)
9	Gray wolf (*Canis lupus*)	2	Black bear (*Ursus americanus*)
9	Ruffed grouse (*Bonasa umbellus*)	2	Bonytail (*Gila elegans*)
8	Black-tailed prairie dog (*Cynomys ludovicianus*)	2	California condor (*Gymnogyps californianus*)
8	Whooping crane (*Grus americana*)	2	Cape Barren goose (*Cereopsis novaehollandiae*)
7	Fox squirrel (*Sciurus niger*)	2	Chinook salmon (*Oncorhynchus tschawytscha*)
6	Desert pupfish (*Cyprinodon macularius*)	2	Colorado squawfish (*Ptychocheilus lucius*)
6	Red wolf (*Canis rufus*)	2	Common brush-tail possum (*Trichosurus vulpecula*)
6	Red-cockaded woodpecker (*Picoides borealis*)	2	Common wombat (*Vombatus ursinus*)
6	Wood duck (*Aix sponsa*)	2	Eastern barred bandicoot (*Perameles gunnii*)
5	American alligator (*Alligator mississippiensis*)	2	Gambel's quail (*Callipepla gambelii*)
5	Grizzly bear (*Ursus arctos*)	2	Gopher tortoise (*Gopherus agassizii*)
5	Mountain lion (*Felis concolor*)	2	Guadalupe bass (*Micropterus treculi*)

No. of Areas	Common (Scientific)	No. of Areas	Common (Scientific)
5	Osprey (*Pandion haliaetus*)	1	Dekay's brown snake (*Storeria dekayi*)
5	Steelhead trout (*Salmo gairdneri*)	1	Eastern bettong (*Bettongia gaimardi*)
4	Bobcat (*Felis rufus*)	1	Eastern chipmunk (*Tamias striatus*)
2	Harris' hawk (*Parabuteo unicinctus*)	1	Eastern hog-nosed snake (*Heterodon platyrhinos*)
2	Kemp's ridley (*Lepidochelys kempii*)	1	Eastern pygmy possum (*Cercartetus nanus*)
2	Koala (*Phascolarctos cinereus*)	1	Eastern red-backed salamander (*Plethodon cinereus*)
2	Largemouth bass (*Micropterus salmoides*)	1	Eastern spadefoot (*Scaphiopus holbrookii*)
2	Magpie goose (*Anseranas semipalmata*)	1	Echidna (*Tachyglossus aculeatus*)
2	Montezuma quail (*Cyrtonyx montezumae*)	1	Emu (*Dromaius novaehollandiae*)
2	Narrow-faced kangaroo rat (*Dipodomys venustus*)	1	Ferruginous hawk (*Buteo regalis*)
2	Owens pupfish (*Cyprinodon radiosus*)	1	Fiddler crab (*Uca pugnax*)
2	Piping plover (*Charadrius melodus*)	1	Gray treefrog (*Rana clamitans*)
2	Pismo clam (*Tivela stultorum*)	1	Green frog (*Rana clamitans*)
2	Red-legged frog (*Rana aurora*)	1	Gunnison's prairie dog (*Cynomys gunnisoni*)
2	Speckled dace (*Rhinichthys osculus*)	1	Hard shell clam (*Mercenaria mercenaria*)
2	Tasmanian pademelon (*Thylogale billardierii*)	1	Hawaii creeper (*Oreomystis mana**)
2	Tidewater goby (*Eucyclogobius newberryi*)	1	Hawaiian coot (*Fulica americana*)
2	Yaqui chub (*Gila purpurea*)	1	Hawaiian goose (*Nesochen sandvicensis*)
2	Yellow-billed cuckoo (*Coccyzus americanus*)	1	Hooded merganser (*Lophodytes cucullatus*)
1	Akepa (*Loxops coccineus*)	1	Houston toad (*Bufo houstonensis*)
1	Akiapolaau (*Hemignathus munroi*)	1	Indigo snake (*Drymarchon corais*)
1	Amargosa pupfish (*Cyprinodon nevadensis*)	1	Kit fox (*Vulpes macrotis*)
1	American grayling (*Thymallus arcticus*)	1	Lake sturgeon (*Acipenser fulvescens*)
1	Apache trout (*Salmo apache*)	1	Lake trout (*Salvelinus namaycush*)
1	Aplomado falcon (*Falco femoralis*)	1	Least tern (*Sterna antillarum*)
1	Ash Meadows naucorid (*Ambrysus amargosus*)	1	Lesser prairie-chicken (*Tympanuchus pallidicinctus*)
1	Atala butterfly (*Eumaeus atala*)	1	Lesser siren (*Siren intermedia*)
1	Beautiful shiner (*Notropis formosus*)	1	Long-nosed potoroo (*Potorous tridactylus*)
1	Bell's vireo (*Vireo bellii*)	1	Louisiana pearlshell (*Margaritifera hembeli*)
1	Bennet's wallaby (*Macropus rufogriseus*)	1	Lynx (*Felis lynx*)
1	Bilby (*Macrotis lagotis*)	1	Mallard (*Anas platyrhynchos*)
1	Black-necked stilt (*Himantopus mexicanus*)	1	Milk snake (*Lampropeltis triangulum*)
1	Blue catfish (*Ictalurus furcatus*)	1	Mississippi kite (*Ictinia mississippiensis*)

No. of Areas	Common (Scientific)	No. of Areas	Common (Scientific)
1	Brush-tail possum (*Trichosurus vulpecula*)	1	Molokai thrush (*Phaeornis obscurus*)
1	Brush-tailed rock-wallaby (*Petrogale penicillata*)	1	Mountain quail (*Oreortyx pictus*)
1	Bull trout (*Salvelinus confluentus*)	1	Native hen (*Gallinula mortierii*)
1	Canvasback (*Aythya valisineria*)	1	Noisy scrub-bird (*Artichornis clamosa*)
1	Catfish (-)	1	Northern elephant seal (*Mirounga angustirostris*)
1	Channel catfish (*Ictalurus punctatus*)	1	Northern pike (*Esox lucius*)
1	Chub (-)	1	Oldfield mouse (*Peromyscus polionotus*)
1	Chum salmon (*Oncorhynchus keta*)	1	Oregon chub (*Hybopsis crameri*)
1	Clapper rail (*Rallus longirostris*)	1	Paddlefish (*Polyodon spathula*)
1	Comanche Springs pupfish (*Cyprinodon elegans*)	1	Painted turtle (*Chrysemys picts*)
1	Common box turtle (*Terrapene carolina*)	1	Pecos gambusia (*Gambusia nobilis*)
1	Common merganser (*Mergus merganser*)	1	Plain chachalaca (*Ortalis vetula*)
1	Common moorhen (*Gallinula chloropus*)	1	Porcupine (*Erethizon dorsatum*)
1	Common ring-tailed possum (*Pseudocheirus peregrinus*)	1	Spotted salamander (*Ambystoma maculatum*)
1	Crested honeycreeper (*Palmeria dolei*)	1	Spring peeper (*Hyla crucifer*)
1	Potoroo (*Potorous apicalis*)	1	St. Croix ground lizard (*Ameiva polops*)
1	Purple martin (*Progne subis*)	1	Sucker (*Catostomus sp.*)
1	Pygmy rabbit (*Sylvilagus idahoensis*)	1	Sugar glider (*Petaurus breviceps*)
1	Quokka (*Setonix brachyurus*)	1	Swamp antechinus (*Antechinus minimus*)
1	Raccoon (*Procyon lotor*)	1	Swift fox (*Vulpes velox*)
1	Racer (*Coluber constrictor*)	1	Tarahumara frog (*Rana tarahumarae*)
1	Razorback sucker (*Zyrauchen texanus*)	1	Texas tortoise (*Gopherus polyphemus*)
1	Sacramento perch (*Archoplites interruptus*)	1	Tree swallow (*Tachycineta bicolor*)
1	Sandhill crane (*Grus canadensis*)	1	Virginia opossum (*Didelphis virginiana*)
1	Scrub jay (*Aphelocoma coerulescens*)	1	Western bluebird (*Sialia mexicana*)
1	Sea otter (*Enhydra lutris*)	1	Western grey kangaroo (*Macropus fuliginosus*)
1	Skunks (*Mephitis ?*)	1	Western pond turtle (*Clemmys marmorata*)
1	Smoky madtom (*Noturus baileyi*)	1	White-faced ibis (*Plegadis chihi*)
1	Smooth green snake (*Opheodrys vernalis*)	1	Woodhouse's toad (*Bufo woodhousii*)
1	Snail (*Lymnaea bonnevillensis*)	1	Yaqui catfish (*Ictalurus pricei*)
1	Snapping turtle (*Chelydra serpentina*)	1	Yellowfin madtom (*Noturus flavipinnis*)
1	Sockeye salmon (*Oncorhynchus nerka*)	1	Spotfin chub (*Hybopsis monacha*)
1	Southern brown bandicoot (*Isoodon obesulus*)		

Table 4. Taxonomic breakdown of native animal restoration projects in national parks, national forests, national wildlife refuges, and other protected areas in the United States, Canada, and Australia (see Table 1 for a complete list).

Number of Areas	Class
402	Mammals
298	Birds
87	Fish
21	Reptiles
12	Amphibians
6	Invertebrates

Number of Areas	Order	Representative Species
233	Artiodactyla	Pronghorn, deer, bison
114	Falconiformes	Hawks, falcons, eagles
101	Carnivora	Wolves, bears, weasels, cats
94	Galliformes	Grouse, quail, turkey
46	Salmoniformes	Salmon, trout
45	Anseriformes	Ducks, geese, swans
38	Rodentia	Mice, rats, squirrels, beaver
28	Marsupialia	Opossums, kangaroos, wallabies
15	Cypriniformes	Minnows, chub, suckers
14	Passeriformes	Songbirds
11	Atheriniformes	Pupfish
11	Gruiformes	Cranes, rails
9	Anura	Frogs, toads
9	Testudines	Turtles, tortoises, sea turtles
7	Squamata	Snakes
6	Charadriiformes	Puffins, sandpipers, gulls
6	Perciformes	Bass, sunfish
6	Siluriformes	Catfish
5	Crocodilia	Alligators, crocodiles
5	Piciformes	Woodpeckers
3	Caudata	Salamanders
3	Pelecaniformes	Pelicans
2	Acipenseriformes	Sturgeon
2	Gastropoda	Snails
2	Pelecypoda	Clams
2	Psittaciformes	Parrots

1	Ciconiiformes	Herons, egrets, ibises
1	Cuculiformes	Cuckoos
1	Decapoda	Crabs
1	Hemiptera	True bugs
1	Lagomorpha	Rabbits, hares
1	Lepidoptera	Butterflies, moths
1	Monotremata	Echidna, platypus
1	Strigiformes	Owls
1	Stuthioniformes	Emus

Number of Areas	Family	Representative Species
182	Bovidae	Bighorn sheep
108	Falconidae	Peregrine falcon
106	Phasianidae	Wild turkey
88	Cervidae	Elk
81	Mustelidae	Martin, ferret
58	Salmonidae	Salmon, trout
54	Anatidae	Canada goose
32	Accipitridae	Bald eagle
29	Antilocapridae	Pronghorn
27	Sciuridae	Black-tailed prairie dog
17	Canidae	Gray wolf
15	Cyprinidae	Chub
12	Castoridae	Beaver
12	Macropodidae	Bennets wallaby
10	Cyprinodontidae	Amargosa pupfish
10	Felidae	Bobcat
9	Gruidae	Sandhill crane
7	Phalangeridae	Brush-tail possum
7	Ursidae	Black bear
6	Colubridae	Dekay's brown snake
6	Ictaluridae	Carfish
6	Picidae	Red-cockaded woodpecker
5	Alligatoridae	American alligator
5	Centrarchidae	Guadalupe bass
5	Heteromyidae	Giant kangaroo rat

Number of Areas	Family	Representative Species
4	Fringillidae	Akepa
4	Muscicapidae	Eastern bluebird
4	Peramelidae	Bilby
4	Poeciliidae	Gila topminnow
4	Rallidae	Clapper rail
4	Ranidae	Green frog
3	Alcidae	Atlantic puffin
3	Emydidae	Common box turtle
3	Pelecanidae	Brown pelican
3	Psittacidae	Thick-billed parrot
3	Testudinidae	Gopher tortoise
3	Veneridae	Hard shell clam
2	Bufonidae	Houston toad
2	Cathartidae	California condor
2	Catostomidae	Sucker
2	Charadriidae	Piping plover
2	Cheloniidae	Kemp's Ridley seaturtle
2	Cuculidae	Yellow-billed cuckoo
2	Gobiidae	Tidewater goby
2	Hirundinidae	Purple martin
2	Hylidae	Gray treefrog
2	Tytonidae	Barn owl
1	Acipenseridae	Lake sturgeon
1	Ambystomatidae	Spotted salamander
1	Atrichornithidae	Noisy scrub-bird
1	Burramyidae	Eastern pygmy possum
1	Chelydridae	Snapping turtle
1	Corvidae	Scrub jay
1	Cracidae	Plain chachalaca
1	Cricetidae	Oldfield mouse
1	Dasyuridae	Swamp antechinus
1	Didelphidae	Virginia opossum
1	Dromaiidae	Emu
1	Erethizontidae	Porcupine

Number of Areas	Family	Representative Species
1	Esocidae	Northern pike
1	Fam-pearlshell	Louisiana pearlshell
1	Laridae	Least tern
1	Leporidae	Pygmy rabbit
1	Lycaenidae	Atala butterfly
1	Lymnaeidae	Snail
1	Naucoridae	Ash Meadows naucorid
1	Ocypodidae	Fiddler crab
1	Pelobatidae	Eastern spadefoot
1	Petauridae	Common ring-tailed possum
1	Phascolomidae	Common wombat
1	Phocidae	Northern elephant seal
1	Plethodontidae	Eastern red-backed salamander
1	Polyodontidae	Paddlefish
1	Procyonidae	Raccoon
1	Recurvirostridae	Black-necked stilt
1	Sirenidae	Lesser siren
1	Tachyglossidae	Echidna
1	Teiidae	St. Croix ground lizard
1	Threskiornithidae	White-faced ibis
1	Turdidae	Molokai thrush
1	Vireonidae	Bell's vireo

Overview of Key Findings

The survey results point to a number of research, planning, and administrative considerations that were associated with significantly higher project success rates. One of the strongest links to success was reducing or eliminating the original cause of the species' decline and disappearance. In the restoration projects for peregrine falcon, bald eagle, and other species affected by DDT, substantial effort went into assessing levels of pesticides in the local environment and ensuring that birds had a relatively safe food supply. Other authors point out examples of species that have declined for unknown reasons and for which restoration efforts failed (see Dodd and Seigel (1991) for amphibian species).

Restorations were significantly more successful where managers had information on the habitat requirements of the subject species than where information was lacking (91% vs. 67%). Additionally, managers of successful projects undertook habitat improvement more frequently (29% vs. 19%). Having information on other limiting factors, capture techniques, and the success of other restoration attempts with the species were also associated with a higher success rate.

In the implementation phase of a project, two factors were related to success: (1) releasing larger numbers of individuals and (2) having a source of animals near the restoration site. Pilot releases of the species (before the full-scale restoration) and attempts to reduce the numbers or effects of potential competitors also were helpful.

Successful programs took longer than unsuccessful programs (average 270 days vs. 53 days). The projected project time was also longer among successful projects (average 191 days vs. 41 days). Cost of successful projects was less than projected but more than unsuccessful projects ($51,700 vs. $44,300). Seventy percent (70%) of the work done in-house was successful versus 56% success rate for work contracted. Where other agencies were involved, projects were more often successful when managers of the home agency felt they had adequate oversight and control of the project.

Other authors have discussed the approaches to planning and conducting restorations to improve chances for success. Griffith et al. (1989) analyzed information from Australia, Canada, New Zealand, and the United States and found several correlates of success in the biology and management of animals being restored into their native range. They strongly emphasized habitat quality in the restoration area. Without good habitat quality, restorations have a low chance of success. They also found that restoring rare species was more difficult than for more common species. Restoration projects for native game species were successful significantly more often than for rare species with official threatened or endangered status.

Model Program

Portions of Gateway National Recreation Area consist of reclaimed lands that now support upland habitat that was once characteristic of the area. The area is surrounded by urban development and separated from other natural habitats. Furthermore, the combination of past development, use, and isolation has left a depauperate fauna. The park managers are actively managing the habitat to restore more natural conditions, including an innovative effort to restore virtually the entire reptile and amphibian community that characterized the original habitats.

Managers at Gateway have followed a well thought-out protocol throughout the project. To help preserve unique local gene pools, the species being restored were all obtained from the nearby surrounding area. Also, individuals were taken only from populations that were large enough not to be harmed by collecting or from populations that were in danger of being destroyed by development. Different life stages (eggs, larvae, adults) were translocated, depending on the species and on how the species could be most easily and safely transported. Eleven species of frogs, salamanders, snakes, and turtles were introduced, and most or all seem to be successfully established. The ambitious scope of the project and its impressive success were achieved (in spite of limited funding) because of the dedication of resource managers and the help of a large network of volunteers who collected many of the animals for translocation and release (Cook and Pinnock 1987).

Restoration Guidelines

Is Restoration Appropriate?

Before embarking on a restoration program, one needs to determine whether it is appropriate or practical to restore a particular species. Because of their glamorous nature, restoration projects are frequently given more attention than habitat management or exotic (nonnative) species control. Many authors argued against restoration as a primary management tool (e.g., Dodd and Seigel 1991). They point out the high cost of large-scale restorations and the poor success of many projects. The question becomes one of evaluating the likelihood of success against allocating limited funds.

The importance of a given animal restoration project must be weighed against all of the competing resource projects within the agency's management priorities. The role of the species in the local community should be considered. Priority may be given to the rarity of the species and the potential importance of the project to the species' survival.

The NPS *Natural Resource Management Guideline* (U.S. Department of the Interior, National Park Service 1991) specifies that the following criteria be met for any native animal restoration program:

1. The species originally occurred in the area.
2. Its extirpation was caused by humans.
3. Natural reestablishment of the species is unlikely, but a restoration program has a good chance of success.

The former occurrence of the species in the area should be verifiable in most cases. The boundaries of the original distribution of a species that has been missing for some time may be difficult to determine. Reference to museum specimens and journals of early naturalists may clarify the situation.

The reasons for decline and disappearance of an animal species are frequently difficult to determine and require investigation. One of the strongest correlates with success in our surveys was identifying and mitigating threats to the extirpated species. Projects that did not eliminate or reduce the original cause of the species' decline were significantly less successful that projects that did (90% vs. 51%). It may be desirable with rare species, however, to restore animals even if the cause of extirpation cannot be linked to humans.

The third criterion, the feasibility of the project, requires the most consideration. Feasibility can be examined in terms of factors that can be controlled and those that cannot. In this handbook, we discuss program factors that are subject to some degree of control. Other authors have discussed ecological and life history characteristics of animals that make restoration more or less likely to succeed (Fyfe 1978, Griffith et al. 1989, Kleiman 1989). Some of the biological factors correlated with success cannot be changed. These include:

- generalized requirements (e.g., broad food or habitat range)
- high reproductive output (high rate of increase)
- gregarious or flocking social pattern

Other biological and program factors can be controlled. Aspects of restoration projects that are associated with higher overall success (Fyfe 1978, Griffith et al. 1989, Kleiman 1989) are:

- eliminating or mitigating the original cause of the species' decline
- favorable habitat quality (based on detailed consideration of the requirements of the species being restored)
- restorations into the core of the species' range (rather than at the periphery)
- release of wild-caught (as opposed to captive-reared) animals
- closeness of the source population to the restoration area
- medium-sized or large source population (as opposed to taking the individuals from a small source population)
- an increasing or stable source population (as opposed to one that is declining)
- large numbers of individuals released
- repeated introductions or introduction at several sites in a local area

- concentrating releases in a relatively small area to ensure that the population does not become too dispersed for successful reproduction
- few or no competitors
- limited numbers of predators

Having a large source population increases the chances for successfully establishing the new population (Griffith et al. 1989) and in avoiding harm to the source population. Drawing from a source population that is genetically similar to the extirpated animals provides a population that is adapted to local conditions and maintains overall genetic diversity.

One cannot determine the potential success of a project from a list of species characteristics. Griffith et al. (1989) present a regression equation expressing project success in terms of several biological, life history, habitat, and program variables. They discourage rigorously applying the equation to a single species. For example, peregrine falcons rank as poor candidates for restoration in many regards, but for the last 15 years they have been successfully restored to many parts of their range in North America and Europe (Cade et al. 1988). A broad review of projects for many different species may provide general guidelines, but decisions on specific restorations must ultimately be based on background knowledge for that particular species or for a closely related one (Burke 1991).

Potential problems are associated with reintroducing native species. Managers should consider the following factors when evaluating potential projects:

1. The species being introduced has a favorable chance of survival.
2. If a local subspecies or ecotype still occurs in the area, a different subspecies or type should not be introduced into that same area. The integrity of the local genetic type should be safeguarded where possible.
3. The animals to be introduced should be free of parasites and diseases that would be new to the area. Potential disease problems associated with the proposed restoration should be reviewed, and a veterinary evaluation of the animals that are brought into the area should be provided.
4. The restored species may have significant effects on the community or on other native species in the area of restoration. The proposal should discuss possible impacts of restoration and any remedial measures that may be needed.

The proposal must clearly show that the project has a favorable likelihood of succeeding. The scope and goals of the project must be described in specific terms. The methods, time, personnel, and funding must be adequate for the task and for all reasonable contingencies (Burke 1991).

Setting Goals

The goals for a restoration project must be clear and precise. When a goal is stated only in general terms, motivation for the project may be low, and assessing progress or success for the project may not be possible. Projects should be designed to quantitatively compare the results obtained against the original goal. For example, a goal of establishing a self-sustaining population should be expressed in terms of an estimated population size or minimum number of breeding individuals. Surviving young should be sufficient to replace losses, and the population should reach a stable level or continue to increase.

In addition to the primary goal of reestablishing a species, secondary goals may relate to managing the species in the future or research into its basic biology. Evaluating and refining the capture and translocation techniques and follow-up monitoring methods may be necessary, particularly for species lacking extensive documentation. In some cases, effects of the introduction on other native species or on the natural community should be evaluated. For example, in a restoration project for trumpeter swans at Elk Island National Park in Alberta, Canada, secondary goals included evaluating the homing ability of young swans and adult "guide birds" during migration to determine if the birds would consistently return to the park, documenting the effect of the project on the source population, and assessing the effect of the restored swans on the plant and animal community in the park (Shandruk and Winkler 1989).

Role of Program Managers

Program managers (e.g., park superintendents and regional managers responsible for project funding) have a significant responsibility to ensure adequate project proposals and, once a project is approved, to ensure sufficient funding to complete the work. Restorations are often expensive and usually long-term. Projects that end prematurely suffer a

greatly reduced chance for success, and the animals released in the early phases of work may not survive to establish a viable population. Program managers must make a firm commitment to the project following review and approval of the project proposal.

Planning

Feasibility Study

Detailed feasibility studies are important to successful projects (Berg 1982, Nielsen 1988). Poor planning (or lack of planning) can result in the loss of the released animals and may also have negative impacts on the local plant and animal community (e.g., the introduction of diseases that were not present in the area). If a remnant population of the restored species is still present, interbreeding between the new individuals and the remnant animals may result in the loss of uniquely adapted local types (Southern African Wildlife Management Association 1988).

A feasibility study should synthesize background information and research and should outline the steps for a successful restoration. This process will aid in preparing budgets and in planning time, personnel, equipment, and logistics. Nielsen (1988) provides a thorough outline for a feasibility study. The most important points for inclusion are as follows:

1. project goals
2. specific criteria for evaluating success
3. status of the source population
   - size of the population
   - trend in numbers
   - mortality factors
   - genetic relatedness to extirpated population
4. habitat condition in the restoration area
   - vegetation conditions
   - estimated carrying capacity for the new population
   - predators and other mortality sources
   - other environmental conditions that may affect the population
   - possible consequences of the introduction on the habitat and on local native species (including introduction of new diseases or parasites)
5. minimum viable population
6. capture methods
   - time of year
   - capture techniques
   - number of individuals to move
   - age and sex distribution
7. post-capture handling
   - veterinary examination
   - marking or fitting with telemetry equipment
8. transportation of animals
9. release procedures
   - location of release sites
   - timing and number of releases
   - number of sites
   - possible provision of food, water, or shelter
10. long-term monitoring
    - health of animals
    - mortality
    - changes in the population size
11. possible conflicts with other uses or values of the area
12. permits or cooperative agreements with other agencies

Occasionally, restoration programs are more successful than originally intended. Animals may become established at unexpected distances from release sites (including on private property), or their population may expand to levels that adversely affect the local environment or other native species (Gogan 1991). Feasibility plans must include considering whether population control is acceptable and, if so, what techniques will be used.

Preliminary Research

If the information is not already available, some basic ecological research will be required and should include habitat requirements of the species being restored, home range size and movements, food habits, cover or shelter, potential interactions with competitors and predators, and other potentially limiting factors. A lack or paucity of predators would seem to be advantageous for restorations, but predator absence may also indicate a disruption of the local animal community. In Australia, the lack of native predators (e.g., dingos and aborigines) has resulted in the overpopulation of koalas in some small areas.

Analyses of habitat quality at potential restoration sites should include how well these sites fit the requirements of the species and whether active management could significantly improve the habitat. This research should include an analysis of food supply, water sources, breeding sites, escape cover, and relative abundance of competitors and natural enemies

(Schonewald-Cox et al. 1988). Habitat analyses are often the subjective appraisal of one or more experts on the species. A systematic approach, such as the USFWS Habitat Evaluation Procedure (HEP), yields quantifiable results and provides documentation (U.S. Fish and Wildlife Service 1981, Gogan 1990).

Uncertainties regarding the cause of the species' decline in the area should be investigated. Specific attention should be given to alleviating any causes of the initial decline.

Minimum Viable Population

The concept of a minimum viable population is important in planning a restoration (Gilpin 1987). Given sufficient area and favorable conditions, the introduced population will increase to the natural carrying capacity and then fluctuate around that level. Determining if the carrying capacity is sufficient to allow the population to persist is important. If not, then the restoration will fail.

Effective population size refers to the number of individuals that are contributing to the next generation, expressed in terms of an ideal population with an even sex ratio and individuals that mate at random. Effective population size is less than the actual population size, often much less if a skewed sex ratio or a substantial number of individuals do not breed (Franklin 1980). Fifty individuals have been suggested as a safe level for a population over the short-term, while a population level of 500 is required for long-term viability (Franklin 1980, LaCava and Hughes 1984). To maintain sufficient genetic variation, effective population sizes of several hundred have been recommended (Lande and Barrowclough 1987). The area a population would require can be estimated from known area requirements for the species elsewhere in its range.

Schonewald-Cox et al. (1988) suggests an alternative, empirical approach to determining minimum population size. Regressions have been developed for some species by comparing population counts with area occupied (gray wolf and cougar are analyzed by Schonewald-Cox et al. 1988; also see Mohr 1940). For an area of given size, using these regressions provides an approximate population size expected for the species. The question then becomes, can a population of that size be expected to persist?

Source of Animals and Genetic Considerations

In selecting a source population from which to obtain animals for translocation, a number of biological factors to be considered along with the practical considerations of logistics, cost, and legal restrictions:

1. Experience from previous restorations indicates that wild-caught animals (as opposed to captive-raised) do better and are more likely to survive when they are introduced into a new area (Fyfe 1978, Griffith et al. 1989). Young individuals may also be more adaptable to new situations (Fyfe 1978), and young animals may be less likely to disperse from the new area (Fritts et al. 1985). In addition, removing young animals from the source population generally is less of a loss to the source population than removing adults.

2. In general, the source population should be near the restoration area. Translocated animals are likely to be better adapted to local conditions if obtained nearby.

3. The source population should be genetically similar to the extirpated population that formerly inhabited the area. Mixing different genetic types is strongly discouraged because it may cause a loss of diversity at the genetic level (Grieg 1979, Nielsen 1988) and may result in a population that is ill-adapted or unable to survive the demands of its new habitat (e.g., red deer of mixed genetic stock were not hardy enough to survive the winters in northern Europe (Grieg 1979)). As an exception, Corbin (1978) notes that local populations of birds are much more similar genetically than local populations of fish, amphibians, mammals, and other vertebrates. Although using the closest genetic stock available for a particular restoration is probably best, Corbin suggests that the geographical origin of individuals used for bird restorations is not as important as with other vertebrate groups.

4. The source population used for restoration should be from the central part of the species' range. A number of authors (e.g., Corbin 1978) have noted that marginal populations tend to be less variable and therefore more susceptible to environmental changes and subsequent failure.

5. Animals should be obtained from a source population that is stable or expanding. These animals are more likely to become successfully established when they are translocated (Griffith et al. 1989).

One must also consider the effects on the source population when individuals are removed.

Numbers of Animals and Releases

The number of animals released is an important factor in the success of a restoration effort. Griffith et al. (1989) found the number of individuals brought into a new area was positively correlated with success. Beyond a certain optimum number, however, success appears to level off with increasing numbers of individuals released. If success is not realized after this point, other factors that affect the species should be reevaluated.

The number of individuals moved as part of a restoration project will depend on practical and logistical considerations as well as on theoretical optimum numbers. Table 5 shows the numbers of individuals translocated for projects covered in our survey and success of the projects. This example provides an empirical starting point for deciding the number of animals to translocate. Other authors offer guidance on particular species or groups. For example, successful transplants of medium-sized mustelids (fisher, pine marten, and river otter) involved 30 or more animals (Berg 1982). Boyer and Brown (1988) and Franzmann (1988) provide additional information for large mammal species on number of individuals translocated and success of repatriation.

In addition to the number of animals released, consideration should be given to age structure and sex ratio of the translocated individuals and to the distribution of the release sites. Releases should be concentrated in a local area so that individuals can have social interactions and mate. Many animals, however, will tend to disperse from the area where they were released. Techniques for reducing dispersal include releasing family groups, releasing flocks or other natural groups, and allowing the animals to imprint on the site before they are released (Fyfe 1978). For social species, releasing groups that already have an established organization is best. Such animals could be members of the same herd or family group (e.g., wolves; Fritts et al. 1984) or individuals that were raised or housed together prior to release (Kleiman 1989).

Table 5. Number of individuals released versus success of the project. The ratio is the larger number of animals divided by the smaller; negative numbers indicate that unsuccessful projects released more animals than successful projects.

	Number Released		Number of Projects		
	Unsuccessful	Successful	Unsuccessful	Successful	Ratio
Ungulates	54	48	12	29	-1.1
Falcons and hawks	41	53	2	6	1.3
Carnivores	24	40	7	9	1.7
Game birds	108	209	7	16	1.9
Amphibian and reptiles	5,816*	888	6	6	-6.6
All mammals	43	345	21	47	8.0
All birds	93	945	9	25	10.2
Trout	5,353**	306	4	4	-17.5

* This average includes a project that released >13,000 Kemp's Ridley sea turtles.

** This average includes a project that released >20,000 Colorado squawfish.

Timing of Releases

The time span over which animals are released is significantly and positively correlated with success of restoration efforts (Griffith et al. 1989). Repeated introductions spaced over several months improve the chances that the population will become established. Presumably the risk is spread over a longer period so that if one group of individuals experiences unfavorable conditions, another group may find better conditions. A noteworthy extreme is the National Audubon Society project at Eastern Egg Rock and Seal Islands off the coast of Maine. This project, funded almost entirely by membership and private donations, has continued introductions of Atlantic puffins (which require 4 or 5 years to mature) for 17 years and has now established a population of restored birds breeding on the islands (S. Kress, survey response).

The season or time of year is an important consideration in the restoration. A time or season when food supply is plentiful, when temperatures are not extreme, and when predators and competitors are not too abundant should be chosen.

Funding

Cost will vary depending on the species, the distance of the translocation, the size of the project, and the availability of facilities and personnel. Boyer and Brown (1988) record costs ranging from \$25-\$50/animal for small mammals (fox squirrel, fox, peccary, raccoon) to a few hundred dollars for medium-sized and large-sized mammals (black bear, deer, bighorn sheep, river otter) to \$4,000 for moose.

Because unexpected problems and delays may occur in procuring, moving, and releasing animals into a new area, allowances should be made for an extension of field time and for contingency funding (Nielsen 1988).

Pilot Releases

Whenever feasible, we recommend that pilot releases be incorporated into restoration programs. A pilot introduction, performed after a completed planning effort, allows the testing of techniques and may reveal unexpected problems. For example, the University of Idaho, Department of Wildlife Resources, and the National Bison Range conducted pilot translocations of Columbian sharp-tailed grouse onto the National Bison Range. The planned technique of moving hens with their broods was considered a viable approach, but personnel working on the restoration were not adequately prepared to hand-rear chicks when some of the hens died. Project personnel also learned that cool, wet conditions during the spring (when the translocations occurred) resulted in poor survival.

Implementation

Capture Methods

The choice of capture method will vary with the species involved, and specialized literature should be consulted (see the bibliography section for an entry into this literature). General considerations on the choice of capture methods include susceptibility of the species to particular methods, expertise of project personnel, safety of animals, safety of personnel, and the cost of equipment and personnel. Nielsen (1988) reviews capture techniques and procedures for translocating animals. His review emphasizes mammals, but the general comments apply to other groups as well. Berg (1982) specifically discusses capture and handling of mustelids (fisher, marten, and otter).

Captured Animals, Transport, and Release Processes

In a restoration project, individual animals are likely to be valuable, so the potential for injury and stress should be minimized. Minimum restraint should be used for adequate control. Involving experienced personnel should reduce both stress and injury.

Specific handling techniques and precautions will vary with each species. An outline for handling trapped animals follows (Nielsen, 1988):

1. Manually or chemically restrain the animal.
2. Remove from trap.
3. Assess condition by checking for injuries, respiration, pulse, and body temperature.
4. Treat injuries and other medical conditions as necessary, including appropriate prophylactic medications.
5. Affix marks, tags, or telemetry equipment.
6. Collect any required biological samples (e.g., blood, parasites).
7. Transport to release site or holding area.

Chemical restraint should be conducted only by experienced personnel who are certified to use immobilizing drugs. In any use of chemical capture or restraint, the status of the immobilized animal must be continuously monitored. The animals' eyes should be protected from intense light, and overheating or hypothermia should be avoided. Captured animals may need to be held for short periods for quarantine, for veterinary examination, for arrival of transportation, or for acclimation to the release area. Confining animals at the release site should continue only until the animals have become sufficiently adjusted to minimize threats from predators, poaching, disease, or other factors (U.S. Department of the Interior, National Park Service 1988).

Hard versus Soft Releases

Hard releases involve immediately releasing the animals in the target area. Soft releases include provisions for food, shelter, predator reduction, or other assists--sometimes lasting for several months or more. Providing food and gradual release are standard parts of the "hacking" method that have worked well for many birds of prey. Though Griffith et al. (1989) did not find any significant improvement in success for soft compared with hard releases, a number of birds have increased population levels with supplemental feeding (e.g., trumpeter swans, Japanese cranes, Griffon vultures, and white-tailed sea eagles; Archibald 1978). In general, supplemental feeding is most appropriate when natural food is scarce or contaminated (Archibald 1978).

Manipulating the local habitat is another way to soften the release. According to the analysis by Griffith et al. (1989), habitat improvement measures did not show a significant relation to success. Other authors, however, have found that various habitat manipulations, particularly providing or enhancing nest sites and controlling predators and competitors, may increase chances of success (Temple 1978, and references therein). This difference may be due to the particular species (or higher groups) involved in the projects, or it may be a function of the particular situation or time that the project was undertaken. Efforts to enhance habitat can be useful in some cases, and we strongly recommend them where they seem appropriate.

Whether a release should be hard or soft will depend on the biology of the species and how practical it is to augment local food, shelter, or other factors. These decisions need to be made as part of the feasibility study.

Marking Techniques and Radiotelemetry

We recommend that released animals be marked for future recognition. This practice can be extremely useful in later assessments of population levels, dispersal, mortality, reproductive success, and the attainment of project goals. Specific techniques will vary with the species being restored. Reptiles can be marked by clipping scales or scutes, and both reptiles and amphibian can be marked by clipping a toe. A variety of animals can be marked with metal tags or bands (Bub 1991). An unobtrusive, and largely harmless, means of marking many animals is using PIT tags. These small glass capsules (about the size of a rice grain) house a microchip with a unique numeric code that can be read with a hand-held recorder. The capsules are implanted under the skin with a syringe-type device and are highly reliable. Marking techniques for invertebrates are more limited because of their small size, but a variety of possibilities includes bee tags for hard-bodied animals and wing tags for butterflies.

For larger animals, detailed information on individual species may be obtained by using radiotelemetry (Kenward 1987). This method can provide valuable data on movements, dispersal, and activity patterns.

Record Maintenance

As Griffith et al. (1989) urge, adequate record-keeping and reporting should be required. This practice not only allows the agency to decide whether the project is succeeding and whether further support is justified, but it also ensures that other researchers and managers will benefit from the results and findings of the project (Scott and Carpenter 1987). As a minimum, records should include:

- source population and capture areas
- number of animals captured and released
- sex ratio
- age distribution for species that are possible to age
- general health and specific injuries, diseases, and parasites
- release sites
- dates for capture and release
- personnel involved
- problems encountered

For captive-reared animals, detailed information on parentage, health, and rearing conditions of individuals is usually available. Captive-reared animals may also require a longer and more painstaking adjustment period to the wild. For both of these reasons, released animals should be marked so that they can be individually recognized and their success followed more closely (Brambell 1977, Scott and Carpenter 1987). Data to be recorded for captive-raised animals include:

- source of parental stock
- genetic heterogeneity of the captive-reared population
- rearing and handling techniques
- relatedness of individuals released
- pre- and post-release training or any other form of support given the released population

Monitoring, Evaluating Success, and Reporting

Monitoring a restored population is essential. Monitoring is required to evaluate the success of the project, determine if problems occur, and decide if problems can be corrected or avoided in the future. Aspects of the population to monitor (after Nielsen 1988, Gogan 1990) include the following:

1. changes in population size
2. dispersal
3. habitat and resource use
4. mortality
5. reproduction
6. effects of translocation on habitat and other species in release area

Specific monitoring techniques will vary depending on the species involved and the resources available for the work. Ongoing censuses should be conducted for species where accurate determination of numbers is possible. For species that are difficult to count, searches for sign (tracks, scat, etc.) may be appropriate. Berg (1982) recommends searching for sign for restored fishers and martens.

Many of those returning the detailed restoration survey indicated that monitoring had not been sufficient, often due to lack of funds or personnel. One of the advantages the National Park Service (or other land management agency) has in restoration projects is the presence of permanent staff who are often onsite before, during, and after the restoration. Their services should be used, especially during the monitoring phase of the project. For other agencies, such as state wildlife departments, it is more difficult to justify the time and expense of regularly returning to a field site for follow-up studies and monitoring. We received many reports of little or no follow-up by state agencies.

Permanent, onsite personnel are also advantageous if closure of an area is needed to protect restored animals. A number of respondents noted closures (e.g., of cliff areas for restored peregrine falcons, or of stream areas for restored trout), and policing such areas is easier and more effective with permanent staff.

In addition to a lack of follow-up monitoring, there was a difference in the detail or quality of the work. Unsuccessful projects used presence or absence indicators to judge success most frequently (62%) while successful programs used more detailed population size estimates (63%). This difference seems to reflect the greater commitment (in both funding and personnel) found in projects that were successful.

Evaluating Success

A final evaluation should be conducted for each restoration project. This involves reviewing the goals of the project and comparing them with the results of the monitoring program. This evaluation should not only be an ongoing aspect of the project administration but also needs to occur at the completion of the program.

Reporting

The final step in all restoration programs should be a formal report (e.g., technical report or professional publication) that evaluates and summarizes the project. Unfortunately, most projects are not critically assessed, and valuable information on restorations is lost. Of all the respondents included in our survey, only 20% had produced technical reports on successful restoration projects. For unsuccessful projects, this number dropped to 10%. When the results of a project are not formalized in a report, potential lessons from the work are lost. The investment of time, funding, and personnel in restoration projects is significant, and this last step should not be neglected.

Why Some Projects Fail

As with most conservation projects, often there will be problems of limited information, time, and funds (Diamond 1987). When definite goals have been determined, priorities must be set and decisions must be made concerning what information is needed to achieve project goals. Important areas of research that should be considered include the taxonomic relation of the extirpated population, possibly including genetic relatedness studies.

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Appendix A. Complete Text of Preliminary Survey on Restoring Native Animals and Removing Nonnatives in Natural Reserves.

Restoration

We define "restoration" as the release of native mammals, birds, fish, or other animals (whether wild-caught or captive) in an attempt to reestablish those animals in historic range from which they have disappeared. The species does not have to be rare or endangered. If an animal is native to North America, but it is being introduced outside of its historic range, it should not be included below.

1. Are you currently working on any restoration projects for native animals within your park? (Include projects funded or carried out by an outside agency.)

1 NO
2 YES

Common name	Scientific name (if available)

2. Have you completed any animal restoration projects in your park? (Include both successful and unsuccessful efforts.)

1 NO
2 YES

Common name	Scientific name (if available)

3. Are there native animals which you have seriously considered reintroducing to your park?

1 NO
2 YES

Common name	Scientific name (if available)

4. Do you know of additional native animals (not included above) that formerly occurred in the park within the last 50 years, but are no longer present?

1 NO
2 YES

Common name	Scientific name (if available)

5. Considering the range of other resource management projects in your park, how would you rate the priority of native animal restoration projects? (Circle your answer)

1 LOW
2 INTERMEDIATE
3 HIGH

Removal

We are interested in control or eradication efforts involving non-native ("alien" or "exotic") birds, mammals, and other animals. Removal or control of native species which have become pests should not be included below.

6. Are you currently attempting to control or eradicate any non-native animals within your park?

1 NO
2 YES

Common name	Scientific name (if available)
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________

7. Have you completed any non-native animal control or eradication projects in your park?

1 NO
2 YES

Common name	Scientific name (if available)
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________

8. If there are additional non-native animals that are of management concern in your park, but are not currently the target of eradication or control efforts indicate which ones by circling all the appropriate numbers.

1 PIGS
2 UNGULATES (e.g. axis deer, sheep, goats)
3 CARNIVORES (e.g. cats, dogs, foxes)
4 RABBITS
5 RATS AND MICE
6 OTHER MAMMALS
7 PASSERINES (e.g. starlings, house sparrows, other songbirds)
8 OTHER BIRDS (e.g. pheasants, parrots)
9 REPTILES
10 AMPHIBIANS
11 FISH
12 INVERTEBRATES

Please list those species which are of present concern. (List from greatest concern to least concern.)

Common name	Scientific name (if available)
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________

9. Do you know of any other parks or reserves in your area that are conducting restoration or removal projects?

1 NO
2 YES

Area ______________________________
Address ______________________________

Area ______________________________
Address ______________________________

10. We will be contacting some areas for more detailed information. Would you be willing to assist with this second phase?

1 NO
2 YES

11. Your primary role in the projects noted above: (circle all that apply)

1 PLANNING/DESIGN
2 SUPERVISION
3 FIELD WORK

Your Name: ______________________________

Title: ______________________________

Name of Park/Area: ______________________________

Year park established: __________

Total acreage: __________

Please return the questionnaire by August 30, 1990 to:

Dr. Gary M. Fellers
Research Scientist
Institute of Ecology
University of California
Davis, CA 95616

Phone
(415) 663-8522

Thank you for your help.

Any comments you wish to make that you think would help in developing successful restoration or removal programs would be appreciated.

Please make your comments here or in a separate letter. Thanks.

Appendix B. Complete Text of Follow-up Survey on Restoring Native Animals.

This survey seeks additional information on native animal species which you have restored to your management area. We are particularly interested in the species indicated in our cover letter, but you may substitute another species if you can provide better information. Thanks for your time and thoughts on these questions.

1. Common name ____

2. Scientific name ____

3. In what year was this species last recorded in the project area prior to the restoration?

   ____

4. Does this species have any special status (e.g. rare, threatened, endangered)? (Please circle the appropriate number)

   1 no
   2 yes, Federal ____________________
   State ____________________
   Other ____________________

5. Were (or are) you the lead agency for this project?

   1 no
   2 yes

   If no, who was the lead agency? ______________________________________

6. What caused the species' decline and disappearance? (Circle all appropriate numbers)

   1 habitat loss
   2 excessive hunting or trapping
   3 pesticides or environmental contaminants
   4 disease / parasites
   5 competition or predation from exotic species
   6 unknown
   7 other, please describe

7. Have the threat(s) listed above been substantially reduced or have conditions for the species' survival significantly improved otherwise?

   1 no
   2 yes
   3 unknown

8. Which of the following did you consider as part of your planning process? (Circle all appropriate numbers)

   1 sources of animals
   2 number of animals / number of releases
   3 season for translocations
   4 personnel requirements
   5 funding required and possible sources
   6 political and social concerns

9. Which of the following information did you have for the species being restored?

1 habitat requirements
2 limiting factors
3 capture / handling techniques
4 minimum viable population size
5 success of other restoration attempts

10. From what sources did you obtain information? (Circle all that apply)

1 on-site staff, visitors, or local naturalists
2 off-site government managers / researchers
3 university researchers
4 private consultants or veterinarians
5 government reports or publications
6 professional journals

11. Did any of the active participants in this project have field experience with other restorations or translocations?

1 no
2 yes

12. Did any of the active participants have field experience with this particular species?

1 no
2 yes

13. What was the origin of the animals you used in the restoration?

Source of animals
1 captive raised
2 wild caught

Genetics
1 same race or subspecies
2 different race or subspecies

14. What research did you conduct prior to restoration attempts? (Circle all that apply)

1 potential carrying capacity
2 potential predators
3 disease / parasites
4 potential competitors
5 food availability
6 habitat analysis
7 pilot releases
8 genetic relatedness of the source population to the animals which formerly inhabited the area
9 abundance of other native species in the restoration area
10 other, please specify

15. When did you initiate actual restoration of animals? _______________

16. When did you complete the restoration (not including monitoring)? ______________

17. At how many sites were animals released?

1 1 site
2 2 - 4 sites
3 5 or more sites

18. Over what time span did you release animals?

1 7 days or less
2 7 - 30 days
3 30 - 90 days
4 90 days - 1 year
5 greater than 1 year

19. What was the total number of animals you released? ______________

20. Did a veterinarian or biologist examine animals for disease, parasites, or injuries?

1 no
2 yes

21. How far was the source of the population from the release site?

1 less than 5 miles
2 5 - 25 miles
3 25 - 100 miles
4 100 - 200 miles
5 greater than 200 miles

22. What was the condition of the released animals?

1 good
2 fair
3 poor
4 unknown

23. Did you provide or undertake any of the following as part of the restoration?

1 temporary shelter
2 supplemental food
3 predator reduction
4 reduction of competitors
5 habitat improvement

24. What was the outcome of the project?

1 successful - new population has reached a level considered to be safe and is stable or increasing
2 unsuccessful - new population did not persist or has decreased to the point where it will probably not persist
3 results uncertain - long-term status of population is not yet known or project is still in progress

25. How was the success or failure of your restoration determined? (Circle all numbers that apply)

1 field observations
2 presence of animal sign
3 systematic counts or censuses
4 sighting of tagged animals
5 radiotelemetry tracking
6 other, please describe

26. What follow-up studies were done?

1 presence / absence
2 population size
3 population dynamics (e.g. survival, reproduction)
4 dispersal
5 effects of the restored species on other animals, plants, or habitat
6 none yet

27. By what means have you documented your program and its results?

1 in-house reports
2 technical publications
3 professional publications
4 popular publications / news reports
5 presentations at professional meetings or seminars
6 none yet

28. If your restoration program was not successful, please indicate which of the following were critical factors. (Circle all appropriate numbers)

Administrative factors
1 project terminated prematurely
2 inadequate funding
3 budget cut during project
4 change of personnel
5 change of agency priorities
6 problems with laws and regulations
7 interagency problems
8 political / public relations problems
9 none identified
10 other, please describe

Biological factors
1 dispersal away from release site
2 predation
3 failure to reproduce
4 competition
5 disease / parasites
6 unusual environmental stresses (e.g. fire, drought, flood)
7 none identified
8 other, please describe

29. Do you think the restoration project would be feasible if the above problems were corrected?

1 no
2 yes

30. How much time was originally planned for the project, and how much was actually required / completed?

_______ days anticipated
_______ days actual

31. What was your estimate of the total cost of the project, including temporary and permanent personnel?

$ ____________ anticipated
$ ____________ actual

32. Was the project fully-funded?

1 no
2 yes

33. Please indicate the percentage of funding from each source.

_____% federal
_____% state / provincial
_____% other government
_____% private
_____% other, please specify

34. How was the work on this project divided?

_____% in-house
_____% other government agencies
_____% contract
_____% other (e.g. volunteers)

35. Given the balance of work indicated above, did you have sufficient control and oversight of the project?

1 no
2 yes

36. What were the strong and weak points of this particular project?

strong -
weak -

37. What problems were there which were unique to this particular species?

Your Name ____

Title ____

Name of Park / Area ____

Please return the questionnaire by April 30, 1991 to:

Dr. Gary M. Fellers
Dept. of Environmental Studies
University of California
Davis, CA 95616

Phone
(415) 663-8522

Thank you for your help.

Any additional comments you think would help in developing successful restoration programs would be appreciated. Please make your comments here or in a separate letter. Thanks again.

As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D-1066 June 1995